PRE-ENGINEERING ASSESSMENT OF ENERSOLVE DEMONSTRATION PROJECT

AT

L. E. SHAW LIMITED, LANTZ - NOVA SCOTIA

FINAL REPORT

BY

INTERPROVINCIAL ENGINEERING LTD.

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SUMMARY

The primary objective of this study is to determine the feasibility of applying state of the art control and monitoring system technology to increasing fuel efficiency and decreasing unit costs in the tunnel kiln at L. E. Shaw's brick plant in Lantz, Nova Scotia.

The overiding constraint is production of a good quality brick.

Optimization is dependent upon achieving the most efficient rate of heat transfer into the ware in the pre-heating and firing zones and out of the ware in the annealling and cooling zones of the kiln.

The cost to build a completely new kiln is prohibitive, therefore, upgrading components is the only alternative. Design of a kiln today is based mainly on the same empirical formulas used in the 1950's. Consequently, the fact that modern kilns are more productive is directly relevant to the antiguated unit at L. E. Shaw. Increased productivity has occurred from use of state of the art equipment and application of operating experience gathered in the past twenty-five years. Redesigning the unit at L. E. Shaw to incorporate advances in control and combustion technology that have occurred since 1957 should reduce the fuel bill for the kiln by approximately 48%.

An estimate for the cost of the project is very difficult to determine accurately since equipment costs can only be determined from a detailed design phase. Preliminary equipment estimates vary by as much as five hundred percent between similar systems. Calculating the payback period in the most expensive scenario suggests the system will pay for itself in approximately 1.32 years. We feel that by the time the project is complete a payback period of less than 1 year will actually be achieved as a result of judiscious selection of components from various manufacturers.

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ENERSOLVE DEMONSTRATION PROJECT

L. E. SHAW LIMITED

1. TERMS OF REFERENCE

Authorization and terms of reference for this study are given in contract serial number OSQ82-00106 from Supply and Services Canada to Interprovincial Engineering Limited, dated September 15, 1982. A copy of the statement of work from the contract is included in this report as Appendix 'A'.

2. INTRODUCTION

L. E. Shaw Limited originated in 1861 as a small manufacturer of clay bricks and tiles in Hantsport, Nova Scotia. Currently the company operates manufacturing plants in both Nova Scotia and New Brunswick and its products include, in addition to clay bricks, concrete block and pipe, construction aggregates and industrial sands. For this project we have confined our investigation to the feasibility of increasing the efficiency of utilization of oil in their tunnel kiln at Lantz, Nova Scotia. (See map, Appendix 'B').

The tunnel kiln was designed in the mid 1950's by Hendryx Engineering of Pittsburgh, Pennsylvania and commissioned in 1957. The kiln is designed to operate twenty four (24) hours a day, three hundred and sixty-five (365) days a year. When it was built, the kiln incorporated state of the art design principles; however, in today's technologically advanced society it is considered antiquated. While most of the kiln remains exactly as it was built, some modifications in the early 1970's upgraded the burners in the pre-heat zone and recovered waste heat from the cooling and annealing zones.

The brick produced in the tunnel kiln is excellent. Consequently, any modifications or equipment replacement must be assessed strictly on the basis of increasing L. E. Shaw's ability to remain competative on a unit cost basis with brick manufacturers in other parts of Canada. Access to efficient clean burning natural gas is allowing manufacturers in Ontario to compete in the Atlantic Provinces market since their shipping costs are offset by cheaper energy.

Prior to this study L. E. Shaw had already carried out extensive investigation into various alternatives for reducing their energy costs. Design and construction of a new tunnel kiln incorporating the latest energy saving concepts is not viable due to excessive capital costs. Conversion to coal is not practical due to equipment problems associated with obtaining acceptable efficiencies. There are also environmental implications to study. Conversion to a system utilizing developments in coal liquefaction or coal benefaction awaits development of commercially viable components and is offset by the potential for converting to east coast offshore oil or gas. Utilization of wood chips is technically very attractive; however, L. E. Shaw's plant is not large enough to economically use the smallest size equipment currently available. With respect to changing from #2 diesel fuel to cheaper oils, they are unable to obtain sufficient equipment reliability from the heavier furnace fuel oils. They have even found that their ability to competitively shop for the #2 diesel fuel they currently use is seriously hindered by the quality of product available. High sulphur and contaminant concentration in oils from some parts of the world adversely affect the finish of the bricks that are fired.

On an average, the tunnel kiln uses one point six five (1.65) Imperial gallons of oil per minute or eight hundred and sixty-seven thousand, two hundred and forty (867,240) Imperial gallons per year. In 1957 oil cost six point seven

(6.7) cents per gallon and the annual fuel cost to operate the kiln was fifty-eight thousand, one hundred and five dollars ($58,105.00). In 1983 the price of oil is expected to average one dollar and fifty cents per gallon ($1.50) for a total annual expenditure of one million, three hundred thousand, eight hundred and sixty dollars ($1,300,860.00). Since the tunnel kiln was built, fuel costs have risen approximately two thousand, two hundred and forty percent (2,240%). The quantity of bricks capable of being produced has remained relatively constant at around fifteen million (15,000,000) per year.

Optimization of the fuel consumption in the tunnel kiln is a complex problem that is excaberated by the fact that brick making is as much an art as it is a science. Maintaining the operators ability to modify the kiln's temperature profile for quality differences in the raw materials available is as important as decreasing the unit cost per brick for firing. At L. E. Shaw, obtaining minimum unit costs for products of the same quality was investigated with respect to:

- optimizing combustion efficiency
- optimizing process heating efficiency
- utilizing the most cost efficient fuel
- decreasing firing time per brick

3. KILN DESCRIPTION

At L. E. Shaw's plant in Lantz, there are three different types of kiln used for firing bricks and brick products such as flue liners. Three beehive kilns and two shuttle kilns fire the bricks in batches while a single tunnel kiln is used to fire bricks on a continuous basis.

In batch operations, kilns at atmospheric temperature are loaded by positioning a finite number of pre-loaded cars (eight) or by manually positioning the products individually in a predetermined pattern. The kiln's entrance is then closed and a heating/cooling cycle commences that fires the bricks to the operator's requirements. Combustion is only required during the heating portion of the cycle.

Conversely, the tunnel kiln is designed to move cars of brick through pre-set zones of heating and cooling. The tunnel kiln is approximately three hundred and ten (310) feet long and accommodates thirty-one (31) car loads of brick at various stages of the cycle. Control of the time/temperature profile that the bricks are subjected to is currently achieved by:

- manually setting the push rate at which the bricks are continuously moving;
- automatically and manually varying the fuel flow to the burners in the combustion zones; and
- automatically monitoring and varying the air flow in the cooling zones.

The layout of the kiln and temperature profiles are illustrated in Figure 1, Appendix C. To achieve the best heat transfer possible, the kiln is designed to move the loaded brick cars in the opposite direction to the airflow.

There are no internal partitions within the kiln; therefore, the length of each zone was determined during the design of the kiln and temperatures are achieved by controlling burners, supply fans and exhausts. The kiln is long enough to accommodate thirty-two (32) brick cars; however, only thirty-one (31) can be used since with continuous movement required and closed doors located at either end, partial cars cannot be used. Cars enter the kiln in the combustion exhaust zone. A new car is put in every time the other cars have moved far enough ahead to accommodate it. At the same time a car enters another car will have reached the end of the kiln and will be removed. Movement of the cars is achieved by hydraulically pushing the last car which in turn moves the other cars ahead. The cars are approximately nine and three-quarters (9 3/4) feet long and look like small railway flat cars when unloaded. Each car holds three thoudand seven hundred and thirty-eight bricks.

3.1 DESCRIPTION OF ZONES

When the car loads of brick enter the combustion exhaust zone of the kiln, their temperature has already been raised to approximately three hundred and twenty (320) degrees Fahrenheit in a dryer. The stack above the combustion zone is approximately twenty feet (20') high and the temperature of the flue gas entering the stack is approximately four hundred and twenty (420) degrees Fahrenheit. The combustion exhaust zone is very short and is designed to act as a buffer zone when the doors into the kiln are opened.

In the pre-heating zone, the temperatures are raised to approximately sixteen hundred (1600) degrees Fahrenheit. This is a critical temperature and must not be exceeded since carbon in clay products will only burn off below this point. It is essential to get rid of the carbon, otherwise the finished product will be deformed or will have insufficient strength.

In the firing zone the carloads of brick are raised to their final temperature. The temperature is dependent upon the type of brick being made and will vary from nineteen hundred (1900) to two thousand and forty (2040) degrees Fahrenheit. The control in this zone is also critical since, if the maximum temperature is exceeded, the brick will be destroyed.

The quenching zone is located immediately after the firing zone and is designed to produce fast cooling by circulating high volumes of high temperature air. The temperature in this zone can be safely lowered very rapidly to twelve hundred (1200) degrees Fahrenheit, since the glasses formed in the matrix of the clay bodies are still somewhat pyroplastic and stresses induced by fast cooling will be immediately relieved without deformation.

In the annealing zone, the glass matrix of the brick begins to solidify. From twelve hundred (1200) down to six hundred (600) degrees Fahrenheit the brick must be slowly cooled to allow the glass crystals to properly anneal and to allow a crystalline inversion of the silica part to take place without an abrupt change in size. An abrupt change in size would create excessive stresses within the brick's structure.

In the cooling recirculating zone, the temperature of the brick can be rapidly lowered since the composition is set and stresses will not be induced.

The cooling air supply zone operates very similar to the combustion exhaust zone in that it forms a buffer between the exit door when it is opened and the controlled atmosphere of the cooling zones.

3.2 ATMOSPHERE AIR FLOW DESCRIPTION

A diagram of air flow in the kiln is included in Figure 1 and is arranged to highlight the activity in the kiln which is a flow of air and gasses in the opposite direction to the movement of the cars of bricks.

The amount of cold air supplied to the kiln is controlled by a louver on the cold air supply fan inlet. This louver in turn is automatically controlled by the temperature at a thermocouple midway in the annealing zone of the kiln. A cold air recirculation fan is installed close to the exit end of the kiln where final cooling from six hundred (600) degrees Fahrenheit down to the exit temperature can be accelerated.

Two waste heat offtakes have been provided on the kiln. By manually adjusting dampers, the amount of cold air directed through the annealing zone of the kiln can be controlled. Air flow is reduced by taking more of the cooling air out at the offtake close to the exit of the kiln and is increased by opening the offtake close to the quenching zone.

A waste heat draft control located between the burning and quenching zones automatically controls the draft in the kiln. By opening or closing a damper in the waste heat exhaust duct, the pressure in the kiln at this point is maintained at the setting desired. Normally, the waste heat consists entirely of clean heated air that has acquired its heat in the process of cooling the brick.

Beyond the second waste heat offtake and moving in the direction of the entrance of the kiln, quenching zone fans are located. Automatic controls maintain a constant temperature in the gases used for quenching by operating louvers on the inlet duct that control the amount of air taken from the annealing zone.

Between the quenching zone and the burning zone, a direction of flow control thermocouple is located. This thermocouple maintains control of the combustion exhaust fan damper at the entrance of the kiln. If the temperature is increased by a flow of gases from the burning zone back into the quenching zone, the damper at the combustion exhaust fan opens, increasing the draft on the kiln and causing the direction of the gas flow to move more towards the burning zone and the combustion exhaust fan. If the temperature at the control couple drops below a set temperature, due to too much cooling air moving from the quenching zone into the firing zone, the damper at the combustion exhaust fan will close causing the direction of flow and volume of gases moving from the cooling zone to the burning zone to return to normal. While this control is in operation, the furnace pressure control referred to previously continues to maintain a uniform level of pressure or draft in the kiln.

3.3 COMBUSTION EQUIPMENT DESCRIPTION

The combustion system for the kiln has to achieve two equally important tasks:

- obtain the desired temperature profile through the pre-heating and firing zones; and

- optimize heat transfer by the circulation of air to achieve uniform heating throughout the mass of bricks on each car.

Control of combustion is divided into two zones and is based on the temperature at thermocouples which are read on an indicating instrument through a multiple switching unit. Air pressure is pre-set to each burner and the fuel pressure to each zone is regulated independently.

3.3.1 PRE-HEATING ZONE

There are twenty-four (24) Hauck Manufacturing Company high velocity burners, Model No. HVC115 in the pre-heating zone. Evenly distributed on both sides of the kiln, the burners are sealed into specially designed ignition tiles with primary combustion air and secondary transfer air being supplied through the burner. Air and fuel are channeled into the burner nozzle separately to eliminate the possibility of flashback and the burners are equipped with spark ignited gas pilots to help ensure that they do not go out at a low flame temperature during operation.

Temperatures within the zone are controlled by varying the fuel flow in a common manifold to the burners. The controller is designed to increase or decrease the fuel pressure in response to temperature readings from the crown thermocouple at position eleven (11). Distribution within the zone is achieved during initial set-up by adjusting individual micro-valves on each burner to secure the desired flame temperature when the automatic control regulator is set at the middle of its range. Air/Fuel ratios are set using a portable gauge with a Schrader fitting and referring to the manufacturer's performance curve. Each individual setting is determined by establishing the proportion of air needed to maintain the temperature curve required in combination with individual fuel setting. If it is necessary to increase or decrease the amount of heat in British Thermal Units (B.T.U.'s) liberated in a zone, the air supply setting is adjusted so that more or less fuel can be used while still maintaining the flame temperatures at the burners which are required.

3.3.2 FIRING ZONE

There are forty-four (44) Hauck Manufacturing Company Limited Burners, Model No. 779 F installed equally on both sides of the zone. They are believed to be original equipment installed in 1957 and are controlled similar to the burners in the pre-heat zone. The fuel pressure is increased or decreased depending upon the crown thermocouple reading at position seventeen (17). There is, however, a significant difference in the control of the air. The burners in the firing zone are open to atmosphere and without the high velocity feature of the burners in the preheating zone the transfer of heat is not as efficient. Air to the burners is proportioned automatically by the fuel demand and was determined during the design and manufacturing of the burner. It cannot be monitored or modified.

4. KILN OPERATION EVALUATION

As previously identified, brick making is as much an art as it is a science. Our evaluation is therefore dependent upon the operational parameters established since the kiln was built in 1957.

Currently at L. E. Shaw, the tunnel kiln is used to produce the following bricks at the push rate and maximum temperatures indicated:

TYPE OF BRICK	PUSH RATE	MAX. TEMP.
Grey	2 Hr. 10 Min.	2010^{O}F
Buff	2 Hr. 10 Min.	2040^{O}F
Red	1 Hr. 50 Min.	1900^{O}F
Brown	2 Hr. 30 Min.	1900^{O}F

The time the bricks are actually in the controlled atmosphere of the kiln ranges from approximately fifty-six hours and fifty minutes (56 Hr. 50 Min.) for red brick to seventy-seven hours and thirty minutes (77 Hr. 30 Min.) for the brown brick.

4.1 TEMPERATURE CONTROL EVALUATION

The temperatures within the kiln and the composition of the gas being drawn out of the kiln was monitored over a twenty-four (24) hour period.

For temperature readings the existing fixed thermocouples were utilized since they were located at the only points pertinent to combustion control in the kiln. The temperature indicating system was calibrated two weeks prior to our monitoring period by the manufacturer's (Honeywell) service representative. All the readings observed are tabulated in Appendix "E". For evaluation purposes we identified in Appendix "D" the range of variation recorded at each crown thermocouple position and the percentage difference with respect to the existing operator's desired temperature. The temperature profile for the kiln is graphically presented on Figure 1, Appendix "C". The significance of the observations is in the fact that the operators were unable to follow the profile of the desired temperature with the existing combustion and cooling controls. From numerous other observations over a two month period, it was evident that control was always based on a catch up principle and that balance could not be efficiently achieved due to the number of operators manually adjusting individual burner valves.

The existing combustion control system previously identified in Section 3, is not operating as it was designed to be. There does not appear to be a specific reason for this; however, the affect is to negate the existing control equipment's usefulness. Instead of having the controller adjusted to normal fuel pressure at its mid range, the controller is wide open at normal pressure. This allows the fuel flow to be decreased if temperature in one zone is too high, but does not allow fuel flow to be increased if temperature is below normal. In essence, it is acting as a safety device as opposed to a control device. Manual adjustment of the burners micro valves on the fuel input is required as determined by the individual operator's interpretation of hourly thermocouple readings.

4.2 COMBUSTION EFFICIENCY EVALUATION

The setting of each burner's fuel valve could not be established; therefore, its relative position to a theoretical normal setting cannot be evaluated. Similarly, the setting of the air fuel ratio on the high velocity burners in the pre-heating zone is supposed to be determined from readings taken with a Schrader fitting. From discussions with the operators, it appears that no records exist of the settings being checked since the valves were installed in 1973. No provisions exist to allow the air fuel ratio on the original burners in the firing zone to be monitored and theoretical calculations from design data was not considered to be valid, since the burners are in excess of twenty-five years old and have operated for approximately two hundred and twenty thousand hours.

Maintenance and cleaning of the burners by the operators is carried out as required. Problems, such as blockage of nozzles, is normally determined by observing leaking seals on the backs of burner assemblies. Satisfactory performance is determined from observation of a burner's flame through a site port.

Since information was unavailable to determine efficiency of each of the kiln's sixty-eight (68) burners, the stack gas was monitored for twenty-four hours in conjunction with the temperature data that was acquired. The accuracy of the equipment used is detailed in Appendix "G" and the readings obtained are tabulated in Appendix "F". A theoretical determination of efficiency from the amount of excess air or flue gas composition is not pertinent since the optimum theoretical combustion efficiency does not take into account the requirement of combustion air to also transfer the heat throughout the mass of bricks on each car. The amount of excess air required to do this is very dependent upon the velocities that may be achieved from the individual burners. Since the older burners in the firing zone are open to atmosphere, a theoretical excess air requirement cannot be established. The relevance of the flue gas readings that were taken is found in the fact that negligible amounts of hydrocarbons are present and that there are no significant variations in readings over the twenty-four hour period.

5. FEASIBILITY OF IMPROVING KILN EFFICIENCY

During our evaluation of the kiln's performance at L. E. Shaw, it became apparent to us that an inability to precisely calculate the combustion efficiency was not a hindrance. It was also determined that with the antiquated burners being used, the existing controls are adequate.

Fuel consumption could probably be somewhat reduced by setting the control system to the manufacturer's specifications and requiring the operators to adhere more closely to the many considerations involved in "Good Engineering Practice"; however, the practicality of instituting the changes would be questionable. Manpower requirements to set up and maintain the control system as specified, repair minor equipment defects, identify and analyse potential problems and supervise and

administer the details of the program on a continuing basis year in and yet out would be extensive. With fuel expenditures currently in excess of One Million Dollars a year, the annual cost reduction would probably be significant to management; however, the benefits would not be obvious to the watchkeepers responsible for the implementation of the program on a day to day basis. Without a method of monitoring performance at any random point in time, insufficient motivation would be available to operators to assure adherence to new procedures. After the initial novelty of the program wore off, the efficiency of the kiln would probably revert over a period of time to its existing state.

Installing modern solid state control equipment on the existing burners and reducing manpower requirements via extended instrumentation is not an acceptable option. Only a small percentage of the available savings would be tapped and equipment costs would not vary significantly from those required to fully upgrade the facility. Our preliminary estimates indicate simple payback periods would be unacceptably long (i.e. 6 years plus).

Conversely, we estimate that a detailed design study, equipment acquisition and commissioning of a totally new burner system with integrated solid state monitoring and control for all the controllable variables within the kiln would pay for itself in approximately fifteen (15) months. The following analysis is very general; however, the potential for increased productivity is based on the performance of tunnel kilns operating with state of the art equipment in Western Canada and the United States. Discussions with Mr. Gordon Faye, President of Hendryx Engineering in Pittsburgh, has helped to confirm our belief that an upgrading project would be economically feasible. Mr. Faye is an expert in kiln design and his firm designed the tunnel kiln at L. E. Shaw in the 1950's. He has remained thoroughly familiar with its operation to date

through design of the modifications that took place in 1973 and via involvement as a consultant on operational problems. His firm also designed the two modern shuttle kilns installed in L. E. Shaw's plant.

Mr. Faye has expressed an eagerness to assist Interprovincial Engineering Limited in the next stages of this project.

5.1 SAVINGS

Installation of new burners and an integrated fuel system will provide savings via:

- improved combustion efficiency; and
- improved heat transfer with a resulting increase in productivity.

Installation of state of the art burners will increase efficiency in the firing and pre-heating zones proportional to the advances in burner technology that have occurred since 1957 and 1973 respectively. Additional savings will accrue by installing within the system a capability to adjust to the specific B.T.U. content of the fuel and air density changes associated with atmospheric conditions. We estimate that a savings of twenty percent (20%) is achievable with new burner equipment and that the solid state monitoring and control equipment will maintain maximum efficiency on a continuing basis.

20% of $1,300,860 = $260,172 saved per year

Of even more significant impact is the potential for increased productivity. Installation of modern high velocity burners throughout the firing and pre-heating zone will dramatically improve the heat transfer that takes place. The position and number of new burners that will be required will have to be established through detailed analysis by the kiln designer. Recognizing the individual characteristics of clay materials in different parts of the world and taking into account the problems encountered with the high level of oil in the New Glasgow Shale used for the brown bricks at L. E. Shaw, experience in other plants in North America prove that, with proper heat transfer, significantly faster firing cycle times can be achieved. As previously identified, the time to produce red brick in the L. E. Shaw tunnel kiln is approximately 56 hours and 50 minutes. In the similar kilns in the United States, red brick is fired in 24 hours which is a difference of 58 percent. Taking into account constraints that will arise during detailed design of a retrofit system, it is still reasonable to expect that the amount of fuel required to fire L. E. Shaw's existing annual production run of bricks could be reduced by 35 percent. Value can be estimated by applying this saving to the annual operating costs, less increased combustion efficiency.

35% of ($1,300,860 - $260,172) = $364,240 saved per year

How the value of increased productivity is utilized by L. E. Shaw will depend upon the state of the economy and market forecasts. If there is an increased demand for product the kiln may still operate 365 days a year; however, the unit cost per brick will be reduced. If no demand for increased productivity can be foreseen, direct savings in operating costs can be achieved by utilizing the kiln at maximum productivity for only a portion of the year with inventory meeting kiln downtime. Alternatively, when re-designing the combustion system productivity

could remain constant by decreasing the total number of burners with a proportional decrease in fuel requirements.

Total savings that will accrue from installing new burners and an integrated monitoring and control system is:

Improved Combustion Efficiency	-	$260,172
Improved Productivity	-	$364,240
TOTAL	-	$624,412

This represents an overall increase in efficiency in oil utilization of forty-eight percent (48%).

$$\frac{\$624,412}{\$1,300,860} = 48\%$$

5.2 COST OF UPGRADE PROJECT

It is impractical at this point to identify specific equipment requirements since everything hinges on the design of a totally new combustion system for the kiln. We therefore approached various manufacturers with our basic requirements to determine general system availability and ball park costs. The most sophisticated and highly refined system compatible with our requirements appears to be Bailey Meter's Network 90. At the opposite end of the scale are custom systems made up of individual components from various manufacturers. Price estimates for the control equipment ranged from $100,000 to $500,000. Costs are high due to the large number of potential monitoring points required and large number of controllers needed for the individual burners. Similarly, engineering costs will be high due to the extensive design requirements, both for the combustion system re-design and the control equipment design. The cost

for combustion equipment will be the same regardless of control requirements as long as a totally integrated solid state system is utilized. If new combustion equipment is installed without solid state control, the cost for analog controls would have to be added.

ITEM	PROJECT COST
Combustion Equipment	$ 150,000
Monitoring/Control Equipment	$ 400,000
Installation Charges	$ 75,000
Engineering (Including Programming)	$ 200,000
TOTAL	$ 825,000

5.3 PAYBACK PERIOD

The easiest method of establishing the economic credibility of implementing the retrofit requirements is calculation of the simple payback period. While this very basic method of analysis does not take into account the cost of money, the inflation rate or methods of funding it has proven to be a very accurate initial estimate in similar projects throughout the world. Increasing costs for conventional hydrocarbon fuels and the value of the money saved, normally balances carrying charges on initial capital and design expenditures.

$$\frac{\text{Projected Costs}}{\text{Projected Savings}} = \text{Payback Period}$$

$$\frac{\$825,000}{\$624,412} = 1.32 \text{ Years}$$

5.4 PROJECT COSTS BY PHASES

PHASE I	-	Pre-Engineering	- $ 12,000
PHASE II	-	Detailed Engineering and Costing	- $150,000
PHASE III	-	Installation and Commissioning	- $625,000
PHASE IV	-	Monitoring	- $ 50,000

6. CONCLUSIONS

Optimization of combustion efficiency is technically and economically attractive on a large scale. Existing burners must be replaced with state of the art equipment and sophisticated monitoring/control instrumentation is required to ensure the combustion system components are efficiently used on a continuous basis.

Optimization of the process heating efficiency will only result from improved circulation control of the air transferring heat within the kiln. This will be achieved via use of new sealed burner units; however, intensive design investigation and operational evaluation in conjunction with the kiln's designer will be necessary.

Currently L. E. Shaw is using the most economic fuel option available. Analysis of future developments suggests that their only alternative will arrive at the end of the decade in the form of natural gas from the offshore.

A significant decrease in firing time per brick appears feasible in the tunnel kiln. A management decision would be required to specify how L. E. Shaw would utilize the potential for increased productivity since the design process would have to be very extensive. Equipment requirements could vary dramatically depending if the kiln was redesigned to operate at peak capacity for only a portion of the year or if it was

utilized at the same production rate but with shorter pre-heating and firing zones. In either event, control requirements would be similar in that the operators would need to maintain a capability of changing parameters with respect to quality differences in the raw materials they use.

Solid state microprocessor control equipment is readily available for application to the kiln's process. The magnitude of control required and the hardware necessary to achieve desired results can only be determined as part of the detailed design phase. The sheer size of the combustion and control environment (310 feet long, 68 burners) will require the use of an extensive network of monitoring and control systems. Due to the nature of the process ("as much an art as a science") it is imperative that no monitoring and instrumentation considerations overide the brick makers skill which is largely based on empirical knowledge.

The management and operators at L. E. Shaw are familiar with operations using advanced control equipment therefore, there should be no resistance to use of highly sophisciated controls. Advanced analog controls are already used on their shuttle kiln's and they have toured the new state of the art tunnel kiln at North West Brick and Tile Company in Edmonton, Alberta.

Upgrading the kiln at this time can take into account potential for converting to offshore netural gas, thereby incorporating features to ensure optimization for both fuels.

Monitoring and controlling the tunnel kiln will probably be only the first step in development of a system for total energy optimization throughout the plant. Expansion of the control applications will result from the operators development of an appreciation for the flexability and reliability of solid state technology.

APPENDICES

RFP Preamble and Work Statement "APPENDIX A"

The ENERSOLVE program under which proposals are now being requested is concerned with increasing the efficiency of utilization of oil and gas in industrial boilers, kilns, furnaces etc. It is assumed at the outset that such process heating equipment, particulary if 10 or more years old, may not be operating, or operable, at maximum attainable efficiency of fuel use, and that some scope may exist to technically upgrade the installation to achieve greater fuel economy. The manner of obtaining more efficient fuel use may vary from the simplistic case of better temperature control instrumentation, to microprocessor control of fuel/air ratios and flow rates to follow process load. It is axiomatic that the cost of equipment retrofit should be recoverable through fuel savings over a period of time acceptable to the equipment owner.

The ENERSOLVE program is intended to support, at zero cost to the owner, a limited number of site-specific retrofit projects in a variety of industrial sectors and regions in Canada. By this means, it is hoped that a fully documented capability for energy conservation will be formulated by the performers, enabling them to subsequently and privately offer such services to industry on a guaranteed pay-back basis. That is to say, given the case histories of the finite number of Federally funded retrofit projects, the performers should be able to offer industry at large a fuels savings package with a guaranteed return on costs over a agreed time frame.

As a first step in examining the feasibility of the concept, performers are invited to submit proposals on an assessment stage on one or a maximum of two, specific sites.

Statement Of Work:

To provide a detailed pre-engineering evaluation of the potential for cost-effective retrofit at L.E. Shaw Ltd., by performing the following:

1. Identify site-specific oil or gas burning industrial units (rated at 20×10^6 Btu/hr or greater) which shows potential for energy conservation by effecting improvements in operational efficiency and which is available for testing and upgrading.

2. Conduct site investigation and tests to establish data on fuel use, combustion efficiencies, process load characteristics with time etc.

3. Conceptualise equipment upgrading and retrofit procedures to improve efficiencies, and estimate cost/benefit impact.

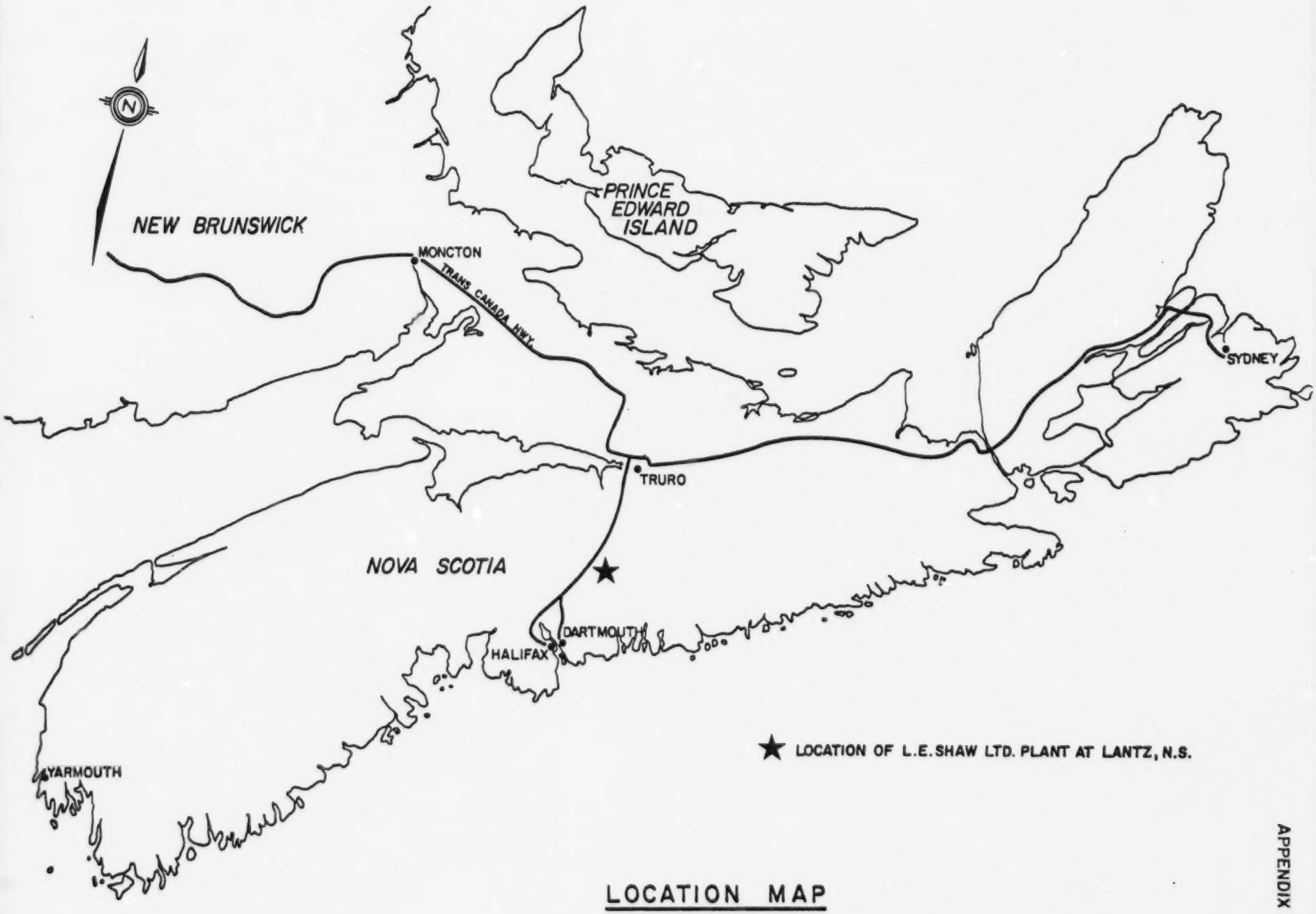
4. Estimate the project costs, at each site, of implementing modifications and monitoring performance in these phases:

   Phase I- Present pre-engineering survey

   Phase II Detailed engineering plan for modifications and costs for Ph III and IV

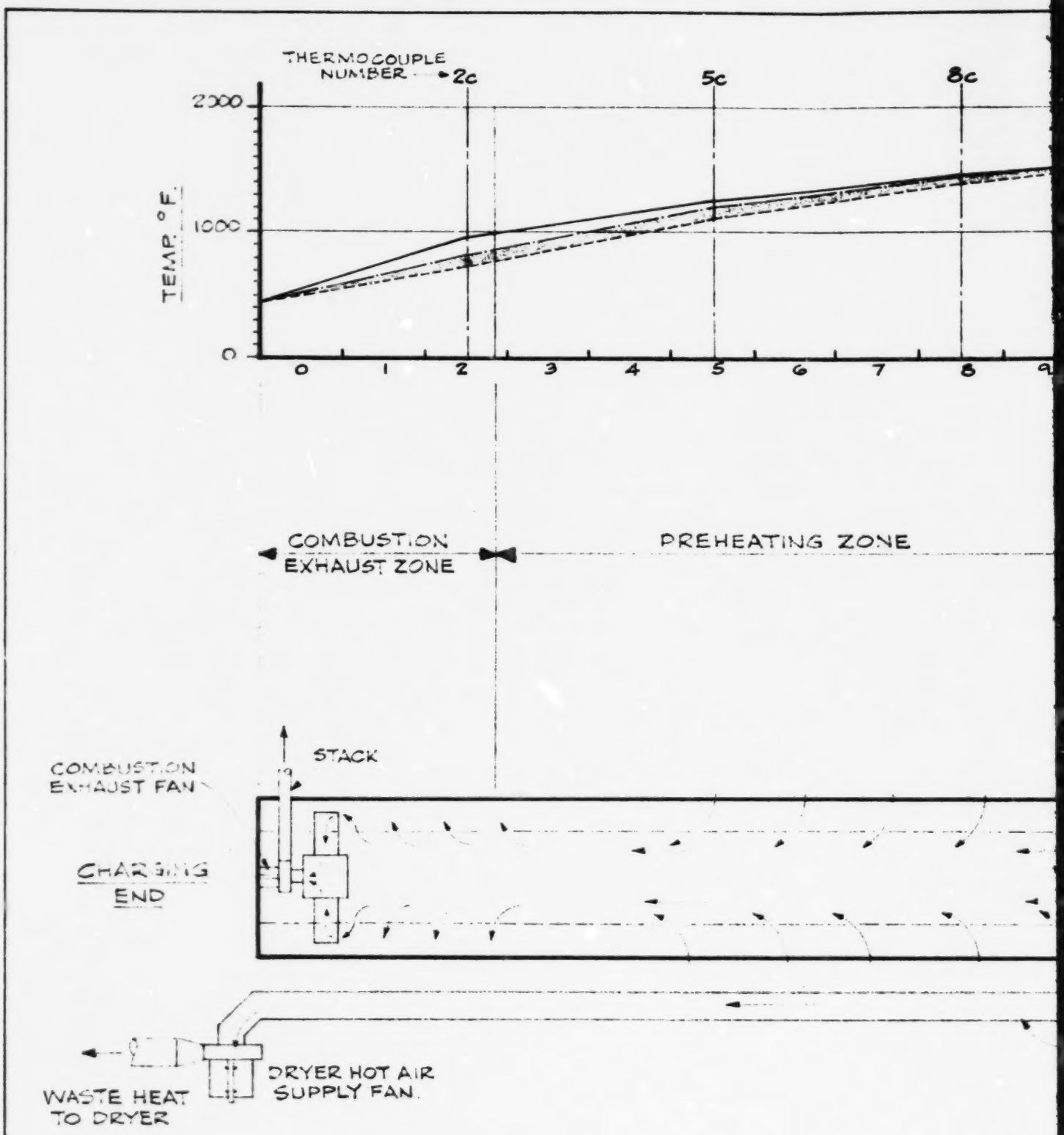
   Phase III Retrofit of equipment and commissioning and acceptance by the owner of upgraded systems.

   Phase IV 9 month monitoring and maintenance of upgraded faculty.

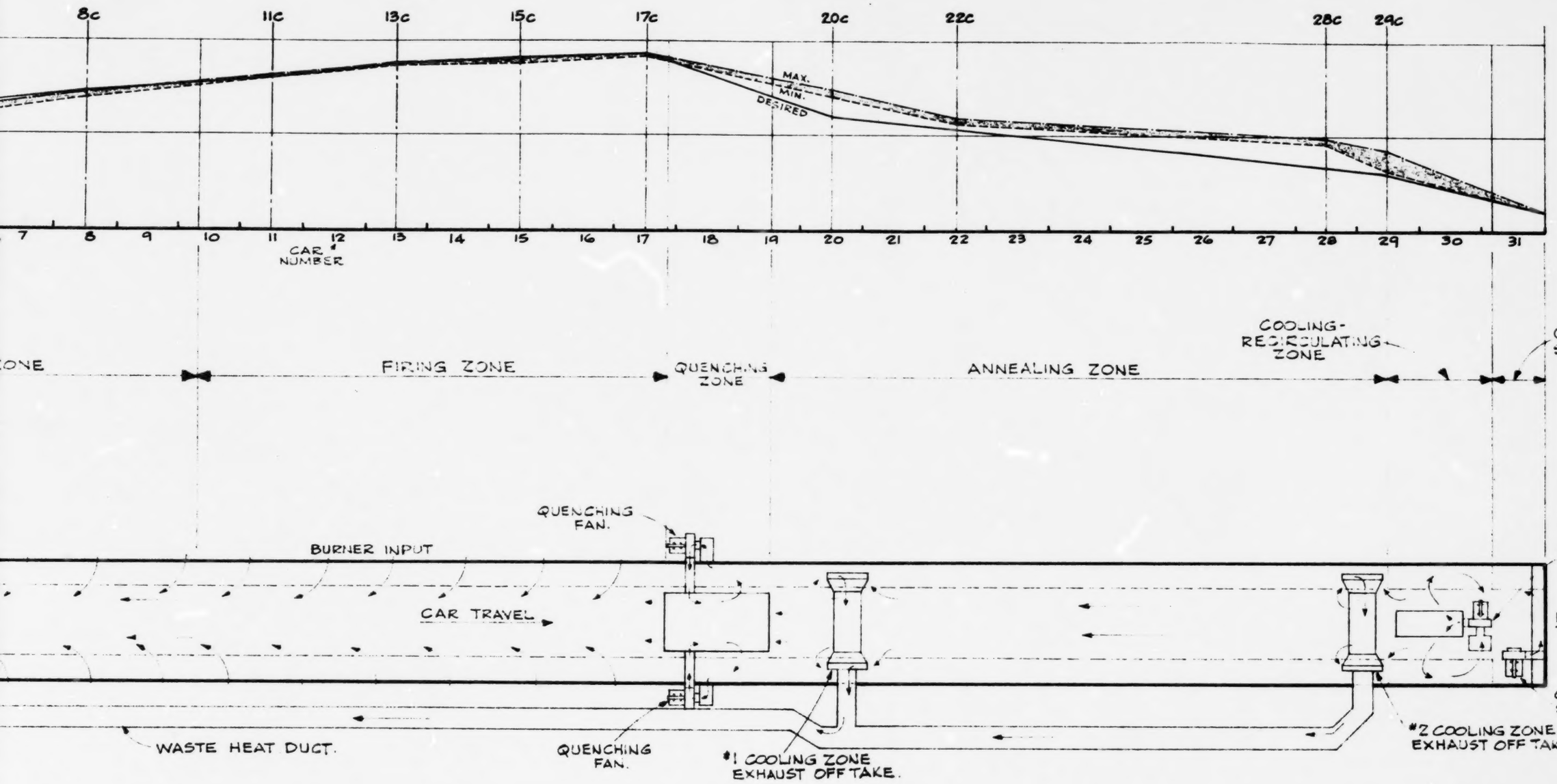


LOCATION MAP

APPENDIX B.


THERMOCOUPLE NUMBER
2c
5c
8c
2000
1000
0
TEMP. °F.
0
1
2
3
4
5
6
7
8
9
COMBUSTION EXHAUST ZONE
PREHEATING ZONE
STACK
COMBUSTION EXHAUST FAN
CHARGING END
DRYER HOT AIR SUPPLY FAN
WASTE HEAT TO DRYER

APPENDIX C.



TUNNEL KILN. (APPROX. 310 FT. LONG)

NOT TO SCALE.

L.E. SHAW TUNNEL KILN DIAGRAM SHOWING GAS FLOW AND TEMPERATURE PROFILE

INTERPROVINCIAL ENGINEERING LTD.

FIGURE 1.

"APPENDIX D"

CROWN THERMOCOUPLE NUMBER (1)	OBSERVED TEMPERATURE MAXIMUM °F	OBSERVED TEMPERATURE MINIMUM °F	MAX/MIN DIFFERENCE %	DESIRED TEMPERATURE °F (2)	MAXIMUM ACHIEVED %	MINIMUM ACHIEVED %
2C	820	725	13	950	86	76
5C	1200	1115	8	1250	96	89
8C	1435	1385	4	1450	99	96
11C	1625	1600	2	1600	102	100
13C	1755	1740	1	1750	100	99
15C	1815	1760	3	1825	99	96
17C	1875	1845	2	1875	100	98
20C	1490	1420	5	1200	124	118
22C	1185	1120	6	N/A	N/A	N/A
28C	985	920	7	N/A	N/A	N/A
29C	850	630	35	600	142	105

TABLE 1 SUMMARY OF TEMPERATURE READINGS IN THE L. E. SHAW TUNNEL KILN FOR A 24 HOUR PERIOD WITH OBSERVATIONS EVERY ½ HOUR (INFORMATION GRAPHICALLY ILLUSTRATED ON FIGURE 1)

NOTE (1) - Crown thermocouples which were calibrated and functional during the observation period.

NOTE (2) - Desired temperature for 2C, 5C, 8C, 11C, 13C, 15C and 17C selected by operator. Temperature for 20C and 29C established from the theoretical cooling requirement described in Section 3.1 (Description of Annealing Zone)

INTERPROVINCIAL ENGINEERING LTD.

L.E. SHAW TUNNEL KILN
LANTZ NOVA SCOTIA

DSS FILE: 17SQ.23440-2-9055.3

DATE: Nov. 08/09, 1982

PRE-ENGINEERING ASSESSMENT OF ENERSOLVE DEMONSTRATION PROJECT

"APPENDIX E"

L.E. SHAW INSTALLED THERMOCOUPLE		2C	4L	4R	5C	8C	11C	13C	15C	17L	17R	17C	17B	18C	20C	22C	24C	24L	24R	28C	29C	30L	30R
TEMP. REQ. / TIME		950	600	600	1250	1450	1600	1750	1825	1825	1825	1875											
1615		785	335	345	1135	1405	1610	1750	1795	1805	1825	1865	220	-	1435	1130		1140	-	935	700	-	175
1645		775	350	365	1115	1405	1600	1755	1800	1810	1845	1865	235	-	1460	1155		1140	-	940	660	-	250
1715		775	325	360	1145	1400	1600	1745	1800	1815	1825	1865	215	-	1425	1130		1135	-	945	690	-	150
1745		790	365	380	1125	1400	1605	1745	1790	1820	1825	1855	210	-	1425	1130		1525	-	940	680	-	210
1815		790	355	395	1135	1410	1600	1745	1780	1820	1850	1850	215	-	1430	1130		1150	-	940	690	-	170
1845		725	345	355	1155	1405	1600	1745	1780	1820	1805	1850	220	-	1435	1130		1260	-	940	690	-	195
1915		760	310	395	1140	1390	1600	1740	1780	1820	1805	1850	220	-	1435	1130		1150	-	940	635	-	190
1945		785	350	390	1145	1395	1600	1740	1760	1720	1810	1850	240	-	1425	1125		1135	-	950	730	-	195
2015		800	315	325	1150	1400	1605	1740	1785	1820	1815	1850	250	-	1425	1130		1145	-	970	690	-	195
2045		725	330	370	1155	1385	1610	1750	1790	1825	1820	1850	260	-	1425	1120		1140	-	935	675	-	195
2115		810	350	380	1150	1390	1600	1750	1790	1820	1820	1850	240	-	1480	1125		1150	-	945	710	-	185
2145		780	310	380	1145	1395	1600	1750	1795	1825	1820	1855	230	-	1425	1125		1140	-	955	745	-	195
2215		740	285	375	1150	1400	1600	1740	1800	1830	1815	1850	220	-	1425	1130		1145	-	955	720	-	200
2245		730	300	385	1165	1390	1600	1745	1805	1835	1815	1870	230	-	1435	1130		1145	-	930	635	-	185
2315		785	340	400	1145	1395	1600	1745	1805	1835	1820	1865	200	-	1435	1130		1155	-	950	725	-	190
2345		785	320	390	1150	1405	1600	1750	1810	1835	1850	1885	200	-	1450	1130		1150	-	930	635	-	190
0015		760	330	320	1170	1395	1600	1750	1815	1840	1835	1860	215	-	1450	1135		1150	-	970	755	-	200
0045		760	375	380	1150	1395	1600	1750	1810	1845	1835	1860	200	-	1490	1185		1145	-	935	700	-	180
0115		765	350	385	1150	1400	1600	1755	1810	1845	1835	1860	215	-	1445	1135		1145	-	920	685	-	200
0145		780	335	375	1150	1415	1610	1755	1815	1845	1835	1860	210	-	1450	1130		1130	-	920	695	-	180
0215		765	330	365	1165	1400	1600	1750	1815	1850	1835	1860	215	-	1450	1130		1130	-	920	645	-	185
0245		765	365	370	1155	1400	1600	1750	1810	1845	1835	1875	220	-	1445	1135		1140	-	930	685	-	180
0315		770	335	380	1155	1400	1600	1755	1815	1850	1835	1860	225	-	1445	1130		1150	-	945	730	-	185
0345		775	315	375	1160	1400	1600	1750	1815	1850	1830	1860	210	-	1445	1140		1155	-	950	695	-	190

INTERPROVINCIAL ENGINEERING LTD.

L.E. SHAW TUNNEL KILN
LANTZ NOVA SCOTIA

DSS FILE: 17SQ.23440-2-9055.3

PRE-ENGINEERING ASSESSMENT OF ENERSOLVE DEMONSTRATION PROJECT

DATE: Nov. 09, 1982

"APPENDIX E"

L.E. SHAW INSTALLED THERMOCOUPLE		2C	4L	4R	5C	8C	11C	13C	15C	17L	17R	17C	17B	18C	20C	22C	24C	24L	24R	28C	29C	30L	30R
TIME \ TEMP. REQ.		950	600	600	1250	1450	1600	1750	1825	1825	1825	1875											
0415		770	340	380	1165	1400	1600	1750	1815	1845	1830	1860	220	-	1450	1140		1155	-	925	650	-	185
0445		805	369	395	1160	1400	1600	1750	1810	1840	1830	1860	210	-	1440	1140		1165	-	940	710	-	180
0515		775	350	385	1160	1400	1600	1750	1810	1835	1825	1850	215	-	1430	1140		1155	-	940	705	-	190
0545		780	330	365	1170	1400	1600	1750	1810	1830	1820	1850	235	-	1425	1135		1150	-	980	780	-	195
0615		785	335	365	1160	1400	1600	1745	1810	1830	1820	1850	240	-	1420	1130		1150	-	920	635	-	190
0645		790	355	375	1155	1400	1600	1740	1805	1830	1820	1850	225	-	1425	1140		1165	-	950	715	-	200
0715		795	360	400	1165	1410	1625	1740	1805	1825	1820	1860	220	-	1435	1135		1155	-	930	670	-	205
0745		805	350	375	1175	1410	1620	1745	1805	1825	1815	1860	260	-	1425	1135		1150	-	950	690	-	205
0815		800	395	395	1165	1405	1615	1740	1805	1825	1815	1855	265	-	1420	1130		1150	-	925	645	-	190
0845		800	380	400	1165	1415	1625	1745	1805	1825	1815	1850	260	-	1430	1135		1160	-	940	730	-	190
0915		810	345	395	1175	1425	1620	1745	1800	1830	1815	1850	280	-	1440	1140		1150	-	940	705	-	195
0945		790	335	335	1185	1420	1600	1745	1800	1830	1815	1845	310	-	1435	1140		1140	-	940	690	-	195
1015		790	395	400	1180	1415	1600	1740	1795	1825	1815	1850	335	-	1430	1135		1145	-	940	630	-	195
1045		815	390	425	1180	1415	1625	1750	1800	1825	1815	1850	325	-	1440	1140		1150	-	950	745	-	190
1115		805	360	400	1185	1425	1620	1750	1805	1830	1810	1855	320	-	1445	1140		1150	-	950	750	-	200
1145		790	335	395	1190	1420	1625	1750	1800	1830	1810	1855	315	-	1435	1135		1140	-	945	640	-	195
1215		805	365	405	1190	1415	1625	1750	1805	1830	1810	1850	310	-	1440	1135		1140	-	935	655	-	175
1245		820	330	400	1185	1425	1625	1750	1810	1840	1810	1855	310	-	1440	1140		1150	-	945	715	-	175
1315		810	340	410	1190	1435	1625	1755	1810	1830	1810	1855	295	-	1435	1140		1160	-	945	740	-	180
1345		805	330	395	1195	1430	1625	1740	1805	1825	1810	1850	305	-	1430	1135		1150	-	930	685	-	180
1415		800	385	395	1190	1425	1625	1740	1810	1825	1810	1850	310	-	1440	1140		1190	-	985	840	-	180
1445		815	325	400	1190	1425	1625	1745	1810	1820	1820	1855	280	-	1435	1140		1195	-	985	840	-	180
1515		805	345	335	1195	1435	1675	1740	1810	1815	1825	1865	295	-	1430	1140		1195	-	975	850	-	195
1545		800	315	345	1200	1430	1625	1745	1810	1820	1830	1870	260	-	1435	1135		1195	-	980	805	-	190

TIME	% (Rounded to Two Decimal Places)						
	CO_2	CO	SO_2 (1)	NO_x (2)	O_2	T.H.C. (3)	N_2
1615	2.56	0.02	0.00	0.00	18.53	0.24	78.65
1645	2.45	0.01	0.00	0.00	17.74	0.01	79.79
1715	2.54	0.01	0.00	0.00	17.68	0.00	79.77
1745	2.52	0.01	0.00	0.00	17.74	0.00	79.73
1815	2.47	0.01	0.00	0.00	17.79	0.00	79.73
1845	2.53	0.01	0.00	0.00	17.68	0.00	78.74
1915	2.28	0.01	0.00	0.00	18.72	0.00	78.99
1945	2.57	0.01	0.00	0.00	17.55	0.00	79.87
2015	2.51	0.01	0.00	0.00	17.70	0.00	79.78
2045	2.48	0.01	0.00	0.00	17.21	0.00	80.30
2115	2.52	0.01	0.00	0.00	17.42	0.00	80.05
2145	2.46	0.01	0.00	0.00	17.61	0.00	79.92
2215	2.48	0.01	0.00	0.00	17.50	0.00	80.01
2245	2.55	0.01	0.00	0.00	17.33	0.00	80.11
2315	2.54	0.01	0.00	0.00	16.96	0.00	80.45
2345	2.47	0.01	0.00	0.00	17.68	0.00	79.84
0015	2.54	0.01	0.00	0.00	16.97	0.00	80.48
0045	2.58	0.01	0.00	0.00	16.95	0.00	80.46
0115	2.57	0.01	0.00	0.00	16.94	0.00	80.48
0145	2.54	0.01	0.00	0.00	17.00	0.00	80.45
0215	2.54	0.01	0.00	0.00	17.02	0.00	80.43
0245	2.57	0.01	0.00	0.00	16.96	0.00	80.46
0315	2.56	0.01	0.00	0.00	17.04	0.00	80.39
0345	2.51	0.01	0.00	0.00	17.12	0.00	80.36
0415	2.49	0.01	0.00	0.00	17.03	0.00	80.47
0445	2.57	0.01	0.00	0.00	16.99	0.00	80.43
0515	2.54	0.01	0.00	0.00	17.20	0.00	80.25
0545	2.48	0.01	0.00	0.00	17.15	0.00	80.36
0615	2.52	0.01	0.00	0.00	17.12	0.00	80.39
0645	2.45	0.01	0.00	0.00	17.22	0.00	80.32
0715	1.74	0.01	0.00	0.00	18.27	0.00	79.98
0745	2.47	0.01	0.00	0.00	17.18	0.00	80.34
0815	2.51	0.01	0.00	0.00	17.14	0.00	80.34
0845	2.49	0.01	0.00	0.00	17.17	0.00	80.33
0915	2.39	0.01	0.00	0.00	17.35	0.00	80.25
0945	2.48	0.01	0.00	0.00	17.26	0.00	80.25
1015	2.55	0.01	0.00	0.00	17.12	0.00	80.32
1045	2.13	0.01	0.00	0.00	17.77	0.00	80.09
1115	2.46	0.01	0.00	0.00	17.31	0.00	80.22
1145	2.48	0.01	0.00	0.00	17.23	0.00	80.28
1215	2.41	0.01	0.00	0.00	17.29	0.00	80.29
1245	2.47	0.01	0.00	0.00	17.26	0.00	80.26
1315	2.42	0.01	0.00	0.00	17.33	0.00	80.24
1345	2.47	0.01	0.00	0.00	17.30	0.00	80.22
1415	2.37	0.01	0.00	0.00	17.42	0.00	80.20
1445	2.42	0.01	0.00	0.00	17.31	0.00	80.26
1515	2.35	0.01	0.00	0.00	17.44	0.00	80.20

TABLE 2 - SUMMARY OF READINGS FROM STACK GAS ANALYSIS

NOTE (1) - SO_2 readings varied from 0.00044% to 0.00360%

(2) - NO_x readings varied from 0.00004% to 0.00321%

(3) - T.H.C. readings varied from 0.00000% to 0.2388%

"APPENDIX G"

MEASUREMENT INSTRUMENT PARAMETERS

CO_2 - Bechman Model 864 Non-dispersive infrared analyzer. Range, in percent: 0-5, 20.

CO - Beckman Model 865 Infrared analyzer.
Range, in ppm: 0-100, 1000
Accuracy 1% of fullscale
Span drift ± 1% of fullscale in 24 hours.
Zero drift ± 1% of fullscale in 24 hours.
Ambient temperature range $-1^{o}C$ to $49^{o}C$.

SO_x - Western Research and Development Model 721A Sulphur dioxide analyzer.
Range, in ppm 0-2000, 10,000
This unit determines the concentration of SO_2 by absorption of UV light.

NO_x - Thermo Electron Chemiluminescent analyzer range in ppm nitric oxide: 0-2.5, 10, 100, 250, 1000 - 10,000.

O_2 - Beckman Model 755 Oxygen analyzer.
Range, in percent: 0-25
Accuracy ± 0.01% O_2 or ± 1% fullscale
Span Drift ± 1% fullscale per 24 hours.
Zero drift ± 1% fullscale per 24 hours.
Ambient temperature range - $29^{o}C$ to $49^{o}C$
This unit is a paramagnetic oxygen measuring system.

HYDRO-CARBONS Scott heated total hydrocarbon analyzer Model 415
Range, 5 ppm to 1% with attenuators for 5, 10, 50, 100, 1000, 5000 and 10,000
Accuracy is 1% fullscale 0.05 ppm
Ambient temperature range $10^{o}C$ to $40^{o}C$
This unit uses a flame ionization detector (FID).

Using Microprocessors To Boost Profits

Rapidly growing technology can help control operations, save labor and prevent malfunctions

By: Gordon Fay, President, Hendryx Engineers, Inc.

Microprocessors represent an important new tool which can help us control brick plant operations more precisely. The use of computers in the accounting and information side of plant operations is already widespread. But greater use of such tools in actual plant functions just now is beginning to take hold.

Let me emphasize that this discussion concerns what microprocessors and computers can do for us in the plant—not how they do it. I'm not an expert computer technician.

We hear a great deal about the wonderful advantages that can come from the use of such tools—but not nearly as much about how this results in a cost savings or other improvements in everyday brick plant operations. For maximum benefit, these units must produce either a labor savings or an improvement in product quality sufficient in size to represent a fairly rapid return on investment. Such benefits are possible, but the microprocessor salesman frequently does not know how to apply theory to the realities of brickmaking.

Three main areas of use

Microprocessors can help us in plant operations in three main areas. First, they can provide dependable automation—and a corresponding savings in labor. Second, they monitor plant operations, giving us the ability to respond instantly to malfunctions. Third, they provide more precise control of operations.

For example, in batching and weighing, they eliminate, or at least minimize, chances of human error. This results in better quality control. We all would like to automate operations more fully. Microprocessors make this more practical and dependable than previously available tools.

In order for the microprocessor to be used to our advantage, it must first fit into an automated operation. The brick industry has the ability to use automatic operations control to a much greater

degree than currently. Industry in general, and the European structural clay products industry, provides an excellent example of automation potential. We trust many things to automation today—from automatic elevators to 24-hr automatic bank tellers—why not then our brick plants?

A brief list of operations in the plant which can be automated would include temperature controls of tunnel, periodic and shuttle kilns; automatic operation of handling systems for kiln cars and dryer cars throughout the process, including dryers, storage areas, kilns and through the unloading area; operation of weighing systems—including both blending and batching; recording and printing of plant records; and a host of other uses.

For years now, automatic controls have been employed in sewer pipe finishing operations. And automatic controls remain an integral part of setting machines and dehacking and blending machines.

Although this is a short list, few plants take advantage of all of these common applications.

Before microprocessors became available, automatic control operations usually fell to combinations of limit switches, pressure switches, relays, timers and temperature sensing equipment. Many automatic operations still rely on these controls.

But the microprocessor came about through a search for a means to improve controls, while lowering maintenance and operating costs. They make automatic control more feasible than ever.

This does not imply that all relays should be replaced by solid-state devices. For heavier loads and low-speed, infrequent circuit changes, relays still work best. They withstand voltage fluctuations better than solid-state.

However, for many of our control needs, the microprocessor or programmable controller fills the bill better than relays. Solid-state devices, with no moving parts, last through millions of operations. Units with moving parts eventually need maintenance or wear out.

A look at the basics

To make practical use of further automation, we first need to take a close look at some of the basics of automating a process. You can't realize the problem until you have a machine that is fast, accurate and—stupid. Unlike human beings, you can't direct it up to a point, then say "Oh, you know."

First, you cannot automate a process unless you have accurate sensors on which to base control of the automatic procedure. Also important—you must have an effective lever which moves automatically when told to. This requires that first you understand what factors the sensors must monitor, and what levers must be operated to secure the desired change.

The electronic engineer who developed the microprocessor, or the man who sells it to us, may know little about the process we plan to automate. That's our job. Any control first requires dependable sensors—thermocouples, limit switches, electric eyes, pressure switch-

Process engineer inserts program into programmable controller using the programming panel.

es and level indicators. Something must tell the controller what's going on.

Secondly, the automatic control system is only as good as the ability of the value sensed—or the factor controlled—to properly influence the result.

Third, the effectiveness and dependability of the control depends on the level of plant equipment maintenance. If the controller works, but the production machine malfunctions, the system obviously won't perform correctly.

Fourth, the effectiveness of the automatic system depends on the dependability of the control unit to function consistently thousands, or even millions, of times.

Fifth, the effectiveness of the automatic control system depends on its own serviceability.

I'll address each of those requirements in turn.

Accurate sensors, thermocouples, limit switches, etc., are now available and will last through millions of cycles.

Selecting the factor to be controlled depends, in large measure, on sound judgment. Many factors are obvious—variation of the fuel supplied to a kiln, for example. But some automation control factors are not as easy to identify. But if an operation can be brought to the attention of a human being, it can be controlled automatically.

Maintenance is always necessary

Maintenance is a basic necessity for any sound operation, whether operated manually or automatically. Failure to provide good plant maintenance should never be a rational reason for rejecting automatic controls.

Since we can easily dismiss the first three factors, as common to both manual and automatic control, the remaining two factors then become the most critical—dependability of the control equipment and availability of service.

On the first subject, microporcessors have come of age, but the time they have been employed in operation of structural clay products plants is not sufficient to provide a large body of information on this specific application.

But at least one microprocessor manufacturer reports the following for one of its most widely used controls:

- On the central control unit, mean time between failures is 59,300 hr.
- On the power supply, mean time between failures is 88,700 hr.
- On the access modules, a mean time between failures is 173,200.
- Input modules, on the average, fail only about every 3.5 million hr.
- For a complete typical system, the mean time between failures is 23,200 hr.
- If you were to operate such a system 24 hr/day, seven days/wk, this means you would have to call for service once every 2¾ yr. And if equipment is duplicated to some extent, the redundancy can extend the mean time between complete system failures.

Most frequent problem would be one of stocking system parts. If an application was critical, the user may prefer to stock his own spare parts.

Availability of service help would be much the same as service provided on other instruments and controls provided by a company. One feature which helps greatly—the equipment often is able to diagnose its own problems. This shortens service time. The repair usually consists of replacing the faulty circuit-board with a new one.

Some new plants are highly automated. In one plant in Japan (not a brick plant), a skeleton crew operates the day

Almost any operation can be controlled automatically

shift and only a night watchman, punching his time clock, is in the plant during the second and third shifts.

Automation for existing plants

But don't think automation on this scale only applies to a brand new plant. Often it can be applied effectively on an existing plant.

In considering the use of automatic control based on microprocessors in a structural clay product plant, it is not necessary that the job be a big, complicated activity. The best starting point is probably not a big, central control unit. Control of individual operations can be comprised of a series of smaller control systems where microcompressors fit in well.

One caution—do not assume that all microprocessors in a plant should come from the same manufacturer. Often one unit fits an application better than another. A total system should consist of a combination of devices, each applying its best advantages to the needs at hand.

There are a number of units available which are designed for specific tasks in heavy clay plants. If they are used in their best applications, they can be installed without causing concern in field maintenance men and electricians.

This is particularly importart. Changes, especially major changes, rarely happen overnight or unattended by difficulties. Conjuring up automatic controls requires time, patience and planning. Technological barriers have rapidly diminished, but resistance from managers who feel overwhelmed and threatened by the automation revolution has not.

Guidelines to follow

The following guidelines for use in initiating the use of computers were designed for an office. They apply equally to automated plant operations.

Start small.

Introduce new technology on a department-by-department basis. Don't overwhelm people with vast changes.

Proceed gradually. Phase in new automated systems and services rather than introducing them all in one indigestible lump.

Introduce automation only into those areas where benefits are immediately needed and readily evident.

Consult the potential operators before you begin. Let them have a say in the system they will be operating.

Provide heavy and continuous training in the use of the new system, both during and after the introductory phase.

Start now. Moving into the automated plant of the future takes time for phasing-in and adjustment. The sooner the transition begins, the sooner higher productivity and higher quality will show up and provide a return on investment.

The question everybody always asks is "How much labor will I be saving?" This depends first on how much labor was required to operate a system before microprocessors were considered. In a face brick plant, it is reasonable to suggest that a grinding plant can be (in fact, often is) run by one man using microprocessor controls. Batching, blending, mixing and extrusion equipment also may require just one operator.

On a setting machine, again, only one man is necessary. But he must be augmented by whatever help is required to straighten the setting caused by brick instability or the setting machine's mechanical abilities. But this is not something that is traceable back to the controller.

Dryers, car handling and any kiln also could become the purview of just one man per shift.

Finally, the dehacking operation could be controlled by a single man, again augmented by help to overcome the mechanical limitations of the dehacker and blending machine. This provides a good example of challenge. A microprocessor can run the dehacker, if the dehacker itself is mechanically sound and dependable.

Of course, nothing can be done about lift truck operators if packages or pallets are handled in this fashion. Nor does this include the maintenance and care of the basic production equipment and control system.

Production equipment maintenance should not be any different than that in a plant without automatic controls. However, the controls themselves require supervision by someone who understands the programming of those controls. Also needed—an electrician who understands how to service the microprocessors.

You don't have to be a Ph.D.

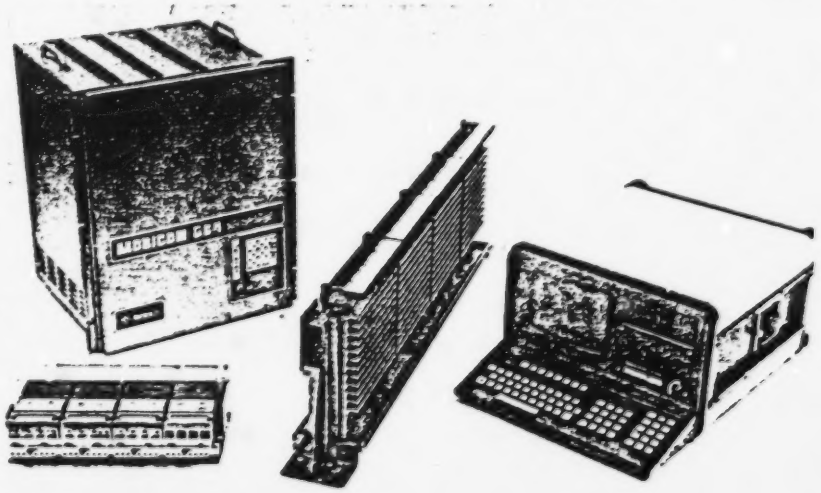
But don't think you need a Ph.D. to understand the programming. This is a somewhat glorified operation, but bears great similarity to the way that you use a 24-hr teller to draw money out of the bank on a Saturday night. Just follow the instructions the computer gives you.

Likewise, electricians need not be supermen. As I mentioned before, one of the beauties of today's control systems is that they perform their own trouble-shooting functions. If they do misbehave, they can identify the location of the trouble. And the controls usually are made up of plug in components or circuit boards. These do not require an understanding of what is actually going on inside. Just the ability to unplug one and plug in another is frequently all that is necessary.

In summary, the use of automatic controls has been available to the brick industry for some time. Now, microprocessors as the central units in an automatic controls system are available to us and a proven quantity.

In many instances, substantial labor savings and return on investment are possible—provided thoughtful applications of these units is made in situations where product quality can be improved or labor eliminated.

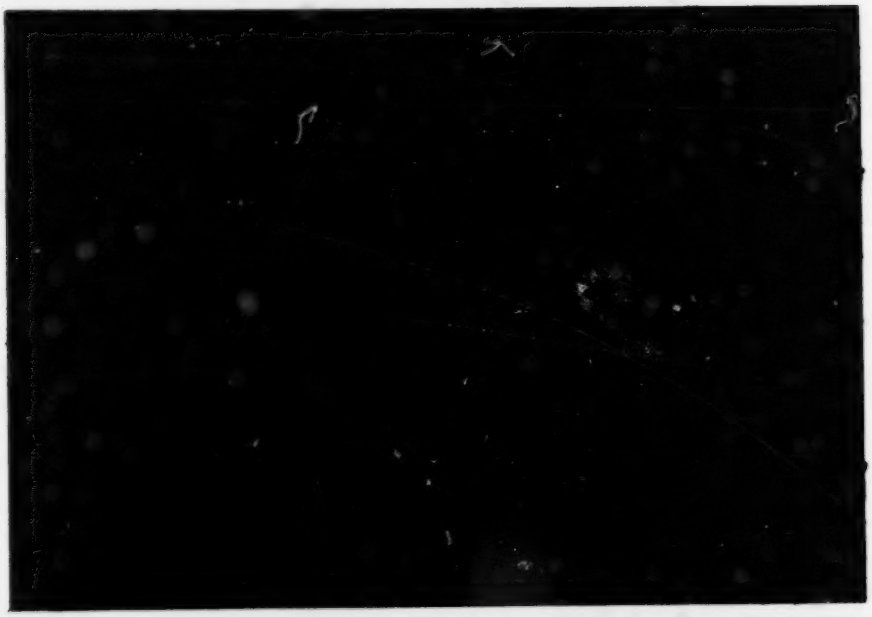
Microprocessors no longer are far-out, unproven gadgets. They are dependable pieces of equipment which can be counted on if properly applied. ■ ■



Programmable controller is latest in technology to increase productivity, decrease maintenance/operating costs and reduce cost of implementation.

Burner in Preheating Zone, showing:

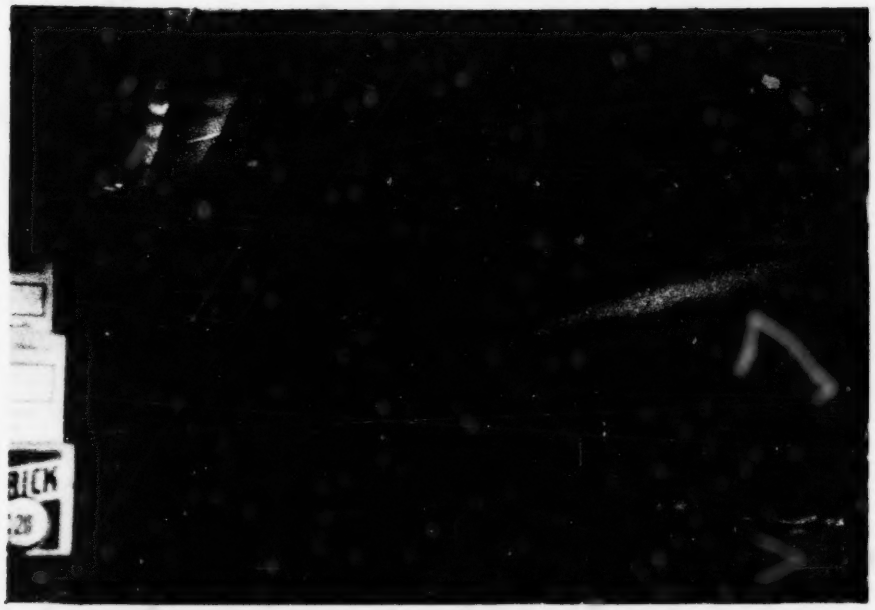
- sealed unit
- primary air
- secondary air
- fuel line



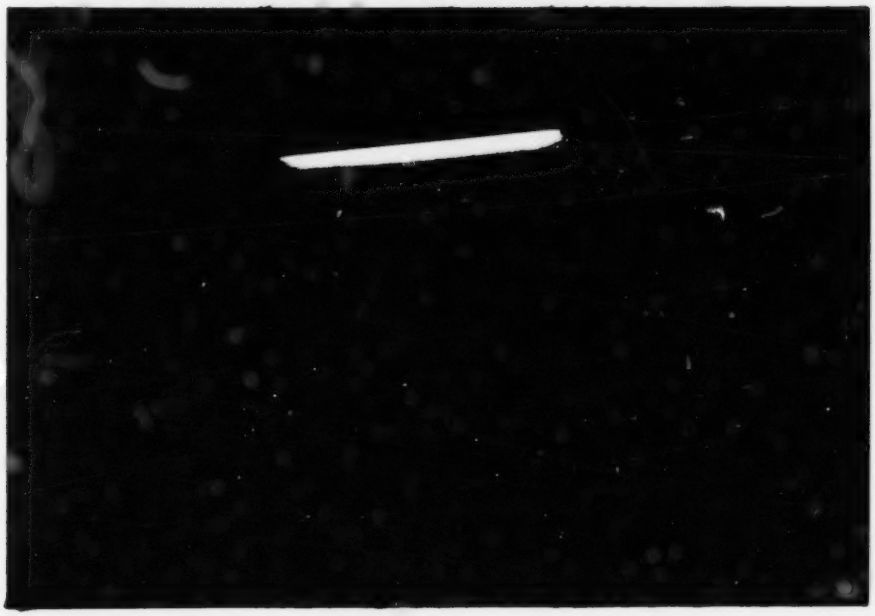
Burner in Firing Zone, showing:

- open flame
- air line
- fuel line

Typical Burner Layout in Firing Zone



Common Air Manifold for All Zones



Existing Monitoring Panel

Small Stack in Center of Picture Exhausts All Tunnel Kiln Flue Gases

POOR

QUALITY

ORIGINAL